

27A Stars and Spectroscopy

How can we use a spectrometer to tell what stars are made of?

With the exception of the Sun, stars appear as small specks of light in the night sky. Astronomers use a technique called spectroscopy to analyze the light emitted by stars. Using spectroscopy, they can determine a star's temperature and the elements from which it is made. In this investigation, you will learn how to analyze light using spectroscopy. You will determine which elements are present in different light sources. You will then analyze the light emitted by the Sun.

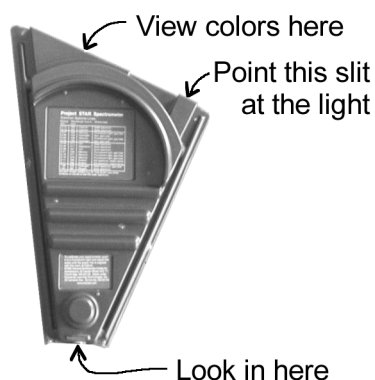
Materials

- Spectrometer
- Colored pencils
- Incandescent light source
- Fluorescent light source

1 Using the spectrometer

A spectrometer splits light into a spectrum of colors and displays the different colors of light along a scale. The scale measures the wavelengths of different colors of light in nanometers (nm).

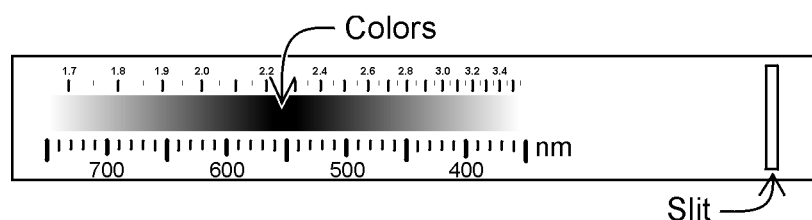
Safety Tip: Never look directly into any light source—especially the Sun!



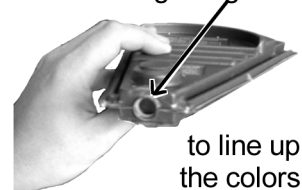
Hold the spectrometer so that the printed side is facing upward. In a well-lighted room, hold the spectrometer so that one eye is looking through the diffraction grating and the other eye is closed. You should see a scale, as illustrated below. The bottom scale measures wavelengths in nanometers. You should also notice colors at various places inside the spectrometer. This is caused by light entering the spectrometer from different sources.

Notice that the plastic disk that is attached to the diffraction grating can be turned. Looking into the spectrometer, rotate the disk until you see colors in a horizontal stripe to your left. The colors should appear between the two lines of numbers on the

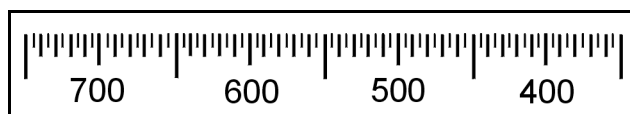
scales.



Rotate the grating here ...



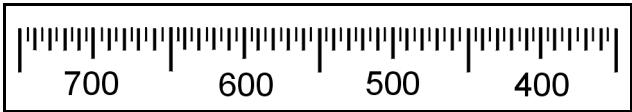
- While looking through the eyepiece, point the slit of the spectrometer directly at an incandescent bulb. Use colored pencils to show where the different colors of light appear on the spectrometer scale.



b. Blue light has the highest energy and red light the lowest. Based on your observations with the spectrometer, what is the relationship between wavelength and amount of energy?

2 Using a spectrometer to identify elements in a fluorescent light

1. Use the spectrometer to examine a fluorescent light source (most likely the ones that illuminate your classroom). This time, you will see vertical lines (called spectral lines) of different colors instead of a smooth spectrum like you observed with the incandescent light.
2. You should see a green line at 546 nanometers on the scale. If the green line is not at 546 nanometers, ask your teacher to calibrate the spectrometer for you.
3. Use colored pencils to sketch the lines you observe. Be very precise in your sketch by placing the lines you see in the exact positions on the scale below.



4. Identify the wavelength of each spectral line, from left to right, then fill in Table 1.

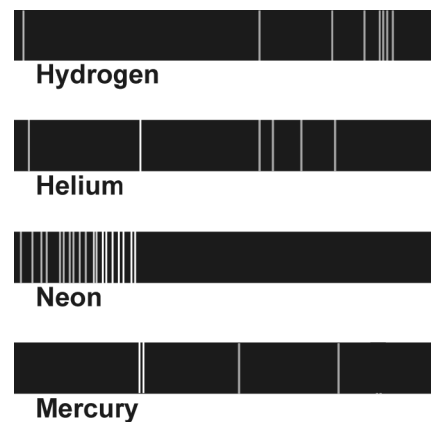
Table 1: Spectral lines produced by a fluorescent light

Line number	Spectral line color	Spectral line wavelength (nm)
1		
2		
3		
4		

What do the lines mean?

When elements are heated until they are hot enough to emit light (like those elements that make up stars), they produce characteristic spectral lines. Each element produces a pattern of spectral lines that is like a fingerprint. Shown to the right are some examples of the spectral lines produced by four different elements. Each line has a specific wavelength (these values are not shown in the diagram).

The light produced by a fluorescent source is created when electric current is passed through a gas inside of the tube. This gas, which is made of only one element, absorbs energy, and emits light.



- The light produced by the fluorescent tube you observed contains only one element. Compare the spectral lines you observed with the ones shown in the diagram above. Which element does it contain?

- Fluorescent tubes have special instructions for disposal and must not end up in a landfill. Based on your spectral analysis of the gas inside the tube, why is this so?

- When astronomers use a spectrometer to analyze the light produced by stars, they observe the combined spectral lines of all of the elements present in the star. What specific information would an astronomer need to know in order to determine which elements are present in a star?






3 Analyzing light from different sources

Identify five different light sources to observe with the spectrometer. Examples include gym lights, street lights, security lights, monitor screens, plant growing lights, and glow sticks. Write the types of light sources in the first column of Table 2. Follow the steps below for each light source.

- Use the spectrometer to analyze the light emitted by the light source.
- Use colored pencils to draw the position of each spectral line in column 2 of Table 2.
- Record the wavelength, in nanometers, of each spectral line in the third column of Table 2.

4. Table 4 on the next page lists the values, in nanometers, of the spectral lines produced by various elements. Use these values to identify the elements found in each light source you observed and write them in the last column of Table 2.

Table 2: Spectral lines produced by different light sources

Light source	Spectrometer scale (nm)	Position of each vertical line (nm)	Elements present
			
			
			
			
			

- a. If one light source displays more spectral lines than another, does that mean that it contains more elements? Explain your answer.

- b. Which light source contains the greatest variety of elements?

- c. Which light sources contain only one element?

4 Analyzing the light from a star

So far, the light sources you observed contain only a few elements. However, stars' atmospheres contain many elements and are much more complex.

1. Use the spectrometer to analyze the light of our closest star—the Sun. Do not point the spectrometer directly at the Sun. Instead, point it at reflected sunlight, off a cloud, for example, or a patch of blue sky.
2. Record in Table 3 the color and value, in nanometers, of each spectral line you observe.
3. Use Table 4, shown below, to identify the elements present in the Sun's atmosphere and record them in the third column of Table 3.

Safety Tip: Do not point the spectrometer directly at the Sun. Point it only at reflected sunlight. NEVER look directly at the Sun!

Table 3: Analyzing light from the Sun

Spectral line color	Spectral line wavelength (nm)	Element present

Table 4: Spectral lines and elements present

Spectral line (nm)	Element present	Spectral line (nm)	Element present
393	calcium	527	iron
397	calcium	546	mercury
405	mercury	577	mercury
434	hydrogen	579	mercury
436	mercury	589	sodium
486	hydrogen	590	sodium
517	magnesium	656	hydrogen
517	iron	687	oxygen

- a. Explain why the Sun's light produces more spectral lines than the light sources you observed in Parts 2 and 3.

- b. Where do elements in the Sun's atmosphere come from? Explain your answer in detail.

- c. The Sun is a middle-aged star. If you could analyze the light from a much older star, what would you expect to see? Justify your answer using your knowledge of the star life cycle.
